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A parametric method to assess the energy performance of the social housing stock and simulate suitable retrofit scenarios: An Italian case study

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ABSTRACT

A deep three-years survey of the existing social housing stock in Emilia Romagna, Italy, has been completed helping to accomplish a full acknowledgement of more than 70 buildings in terms of both their envelopes and heating system characteristics. Analysing the outcome data, a simplified parametric calculation protocol has been created to operate a preliminary audit and energy retrofit simulation on the entire social housing stock of the Region.

The results of the study, initial data about the energy state-of-the-art of the building cluster and feasible retrofit solutions, are useful to identify where to focus for a further and more accurate energy diagnosis.

This paper represents a synthesis of a three-years research work, demonstrating the potential of the parametric assessment method in terms of evaluating environmental and energy benefits, deriving from scheduled retrofit actions, to assist technicians in endeavouring interventions priority.

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1. Introduction

Nowadays, energy is among the principal factors of the social and economic development of our society, dealing with important issues of present times, such as politics and the environment.

The access to an efficient infrastructure system and the distribution of quality services for the end users is the key action in order to pursue a competitive development of the territory. The intense research and technological development, strongly endorsed by public–private partnerships, allows for the access to new resources and new forms of energy, promotes the diffusion of high efficiency and low environmental impact plants and systems, and sets the base for the growth of new enterprises and job activities.

The buildings energy performance improvement, especially regarding the public dwellings, is among the actions that should be pursued to reach the Kyoto and Copenhagen goals.

Such consideration is hereby developed in relation to the social housing stock managed by ACER (Social Housing Agency of the Region Emilia Romagna, Italy), assumed as case studies for the three-years research study, summarized in this paper.

2. Role of the social housing in the energy consumption of the region Emilia Romagna, Italy

In the Region Emilia Romagna (Italy), the residential building sector is responsible for 19.5% (31.6% industry, 48% transportation, 17.1% agriculture, 3.1% services) of the total energy demand (source: ENEA [1,2]).

Within this sector, the energy consumption is divided as follows: 70% for heating system (in relation to social-housing it is mostly heating and it seldom concerns cooling), 10% DHW production, 14% electrical lighting and appliances, and 6% for kitchen use. Such energy consumption could be dramatically reduced introducing Building Codes addressed to energy efficient design for new construction and energy retrofit measures for the existing stock. In this scenario, the necessity of defining effective energy policies for the social housing becomes essential to effectively reduce carbon emission in atmosphere.

Due to the difficulty in pursuing a complete energy assessment of the entire residential sector of the Region Emilia Romagna, but overall because it would be nearly impossible to schedule broad energy-retrofit strategies with a private ownership, the study has

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focused on the social housing stock, entirely managed by public (or semi-public) subjects. A detailed survey, assisted by the district social housing agencies (each Province/District of the Region Emilia Romagna has its own agency), and combined with the indication issued by ISTAT [3] allowed to quantify the social housing properties owned or managed by ACER at Regional level, accounting for 58,395 dwelling units.

The study moves from the broad literature regarding rating methodology to assess energy performances in residential buildings, with particular focus on the statistical approaches [4–7], and applies it to the delimited case study of the social housing of the Region Emilia Romagna. Furthermore, the research proposes suitable actions to improve it. The reduction of the buildings energy demand and carbon emission was pursued through the application of three subsequent energy retrofit packages: primary retrofit of the heating system; refurbishment actions to increase the energy performance of the building envelope (in order to meet the minimum energy level, in accordance to the Regional Regulation 156/2008 [8]); best practice scenario, combination of the two above (especially improving the envelope to a further level, with the aim of achieving high energy performances).

Hence, the research is limited to the analysis of the retrofit actions that allow for an optimization of the sole buildings demand of thermal energy for winter heating. No intervention has been accounted regarding the demand of electricity, supposing it is conventionally provided by the National grid, which is characterized by standard efficiency (data by literature). The reason for such limitation is also to be found in the recommendation of the National legislation, currently requiring the sole calculation of winter energy consumption as a mean to define the global energy performance of a residential building. Moreover, the present study concerns the existing building cluster, and more precisely it focuses only on edifices built before the approval of the Regional Regulation on buildings energy efficiency (endorsement of Regional Regulation 156/2008), assumed as the threshold for a consistent improvement in energy efficiencies for new constructions.

3. Objectives of the study and methodologies

The main objective of the study is to accomplish a preliminary energy performance audit of the social housing stock of the Region Emilia Romagna, and test on it several energy retrofit actions, in order target which situations (individual buildings, housing complexes, or large urban clusters) show the best result in terms of cost/benefit ratio. This procedure will help Social-Housing Agencies identifying where to pursue more accurate analysis, helping them optimizing time and economic recourses.

Such objective can be achieved thanks to a newly elaborated energy audit parametric protocol: surveying only few data, it is capable of providing energy performance results for each building belonging to the social housing stock. The protocol also associates to the energy outcomes three energy retrofit actions, to test their effect on the buildings.

The elaboration of the new energy audit protocol, targeted on the social housing of the Region Emilia Romagna, was based on a bottom-up methodology:

- Identification of enough case studies (different from each other for dimensions, typology, morphology, and technological features) to describe the whole Regional social housing stock (70 buildings have been selected for such purpose);
- Energy analysis of the above 70 case studies, using several calculation methods;
- Identification, thanks to the above analysis, of the characteristics/factors/parameters that mostly influence the social housing energy performance. Therefore, identification of the factors that influence it the least, and can be turned into constant values;
- Elaboration of the new protocol by simplification of the calculation method UNI TS 11300, parts 1 and 2 [9], accounting for the above-mentioned factors;

In the following phase of the research, the result of the bottom-up approach has been extended to the broader Regional stock through a statistical approach:

- Assembly of data set of the whole Region taken from the Regional ACER database;
- Application of the elaborated calculation protocol to the extended Regional social housing stock.

4. Selection of case studies and energy analysis using different calculation methods

As mentioned before, to pursue a bottom-up approach, few case studies need to be selected and deeply analyzed.

70 buildings, chosen for their differences in date of construction, dimensions, shape, technology, heating system, and number of dwelling units, have been selected among the social housing stock managed by ACER Reggio Emilia and ACER Ferrara (Fig. 1).

A full energy diagnosis has been tracked for each case study. To accurately highlight the typological and technological issues that mostly influence the energy performance in social housing, different calculation methods have been used, from a more approximated to a more detailed one:

- Comparisons method, associating the case studies to previously analyzed buildings;
- So-called “real” energy consumption (data collection from previous energy bills);
- Mean steady-state analytical calculation;
- Dynamic-state analytical calculation.

The result-shift between the methods is not the central focus of this paper, however it is relevant to stress what more accurate studies have highlighted [10]: significant differences could be found in the outcomes of the different calculation methodologies; up to 30% shift between results obtained with dynamic-state calculation and steady-state one, which is the methodology currently recommended by the Italian legislation for buildings energy certification. Corresponding studies [11] have also demonstrated how such stringent assessment methods, originally made for a specific geographical/climatic situation, show evident critical issues in applying to other scenarios. Given the above considerations, no energy assessment tool can today be considered suitable for all situations. The presented research starts from these uncertainties to justify the elaboration of a novel energy analysis method. Such calculation protocol would explicitly be a more approximated analysis instrument, and it would only be applicable to a targeted building cluster: the social housing of the Region Emilia Romagna. The necessary approximation in the calculation method has been achieved by excluding certain common-parameters, *i.e.* typological factors (similar in social housing) or climatic characteristics (homogeneous for the geographical Region), which allowed turning calculation variables into constant. The resulting parametric energy evaluation protocol aims to become a preliminary tool for technicians to run first-level urban analysis, in order to target specific clusters that require further examination (by using more complex and detailed systems, *i.e.* dynamic-state calculation method).

For the National and Regional legislation (Legislative Decree 192/2005 and following modifications [12], Regional Regulation

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